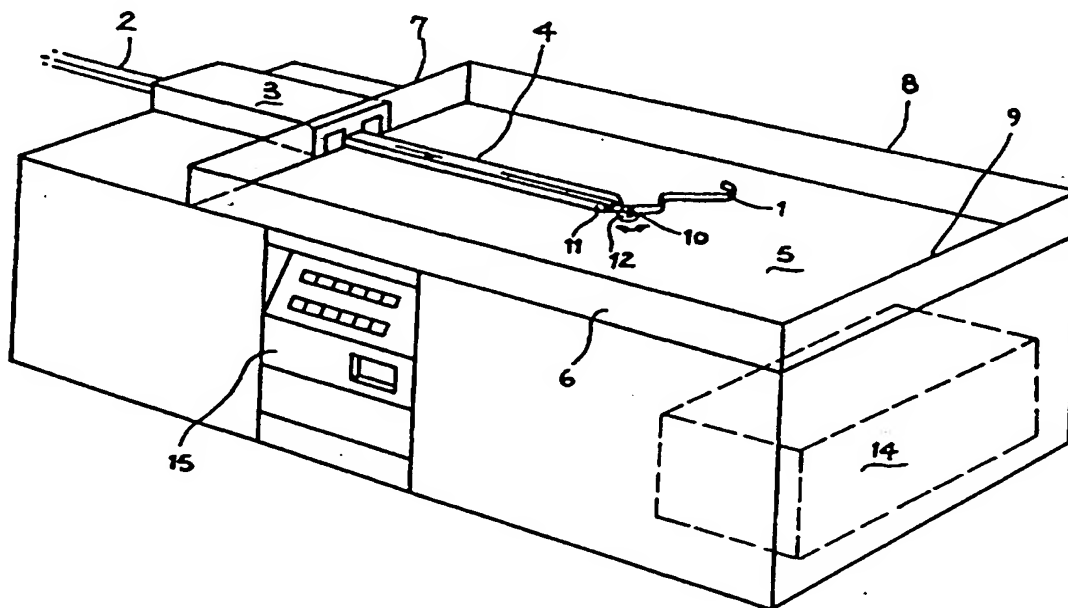


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(54) Title: A PROFILE DEFINITION SYSTEM



(57) Abstract

A profile (23) definition system for use with profile bending apparatus using an imaging process. A profile (23) such as that used to form a cutting knife is located above a non-reflective surface (31) such that the profile configuration (23) can be imaged through a camera (32) substantially mounted above it. The profile (23) being illuminated from above. The camera image being captured by a frame grabber device (35) such that the profile configuration (23) can be compared in comparator means with a desired profile shape. Dependent upon the comparison further profile strip feed and/or bend operations may be performed in order to bring into substantial agreement the actual strip profile (23) and the desired strip profile.

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A PROFILE DEFINITION SYSTEM

The present invention relates to a profile definition system and more particularly to a system for control of knife profile formation produced by forming apparatus arranged to bend suitably fed profile strip.

There are many industries such as those involving shoe or garment manufacture that use punch knives to cut components. These knives are typically formed of double-edged strip steel held within recessed mountings. These knives then stamp out components as required.

Traditionally stamp knives have been individually made by craftsmen in accordance with configurations set by shoe or garment designers. It will be appreciated that a wide range of knives are required even for one shoe or garment style to accommodate the necessary range of sizes.

It will be appreciated that using skilled craftsmen to produce knives is expensive. Furthermore although there may be a range of knives to accommodate sizes there will be elements within each knife that should be consistent to enable automated assembly.

More recently automated knife profile manufacture has been attempted. United Kingdom Patent No. 2,116,086 and European Patent Application No. 83301076.2 illustrate methods and apparatus for manufacturing cutting tools. These automated manufacturing techniques involve feeding profile strip towards a bending station. At the bending station the strip is bent by a moving pin about jaws.

A desired knife profile is translated into a list of profile strip feed and bend operations which are performed sequentially. There is no monitoring of the knife profile actually formed and thus significant deviation occurs in practice from the knife profile required.

Attempts have been made to introduce correction algorithms and limited contact profile sensing to improve performance. However, such approaches fail to address the overriding range of variations in profile strip

characteristics both before bending and after each different bending operation. The best that can be achieved is to average these factors or perform calibration exercises upon the start of the strip prior to bending but even these approaches have been found inadequate to provide knife profiles of sufficient accuracy for industrial use.

A further major cause of error is that typically it is the profile strip face that is monitored. Unfortunately, the actual knife edge is not normally a consistent distance from the face of the strip due to manufacturing requirements and errors. Thus, there may be significant displacement of the actual knife edge compared to that required.

A prior automated knife profile bending apparatus is illustrated in the attached drawing marked prior art. A knife profile strip 1 is fed through a channel 2, a roller straightening device 3 and bending table feed channel 4. A bending table 5 has edge guards 6,7,8,9 to protect the working area. Bending of the strip 1 is performed by a retractable pin 10 mounted upon a rotatable turntable such that the pin when retracted can pass beneath the strip 1 and so present a bending moment upon either side of the strip 1. The feed channel 4 has a sloped exit jaw 11 to maximise the turning range of the pin 10.

The objective of the straightening device 3 is to remove and ameliorate any effects of the strip 1 being coiled prior to knife bending. The coil is not shown in the drawing but is coupled to input channel 2. Typically the device 3 will comprise five smoothing rollers suitably arranged about the strip 1 path through the device 3. After the device 3 the strip 1 is further passed along a straight input feed 4 to the jaws 11. The motive force to propel the strip 1 through channels 2,4 and straightening device 3 is typically a friction dog mechanism mounted either side of the strip 1 such that alternat dogs push the strip 1 towards the jaws 11.

The pin 10 mounted on turntable 12 operates in accordance with a prescribed sequence held within a controller 14. These instructions are loaded into the controller 14 through control panel 15. In use a knife profile is formed simply by feeding

strip 1 in predetermined lengths from the jaws 11 and rotating the pin 10 to a suitable position to bend the strip 1 as required. A series of feed and bend operations should then provide a knife profile.

Originally the turntable 12 upon which the pin 10 is mounted was hydraulically operated but more recently electrical stepping motors have been found more appropriate.

In order to eliminate any distortion effects caused by the formed area of the strip 1 beyond the turntable 12 it is normal for the weight of the strip 1 to be supported by the bending table 5. Thus, the table 5 extends substantially about the turntable 12 to accommodate a wide range of knife shapes and sizes. The guards 6,7,8,9 prevent the knife extending beyond the table 5.

As the knife profile forming process is a simple process of sequential steps with no feedback as to actual results it will be understood that the margin of error both dimensionally and in terms of bend angles is large. Thus, it would be necessary in the past for the final forming process to be conducted by a craftsman. The semi-formed knife profile being taken from the machine and finally adjusted, if possible, into the appropriate configuration. However, although a degree of expensive craft time has been removed from knife manufacture there is still a significant cost and variation between knives in a size range.

It will be appreciated that prior automatic knife profile apparatus has been inadequate for fully automatic operation due to inherent problems of control, accuracy and inconsistency in profile strip as presented at the bending station.

It is an objective of the present invention to provide a control system for an automatic knife profile bending apparatus that substantially relieves the above mentioned problems.

In accordance with the present invention there is provided a profile definition system for control of knife profile formation produced by forming apparatus arranged to bend suitably fed profile strip characterised in that an

imaging device is placed in a substantially perpendicular relationship with at least a part of the profile strip such that an image of the profile strip configuration can be compared with a predetermined configuration stored in comparison means and said comparison means being arranged to adapt said forming apparatus operation as a result of such comparison to bring said profile strip configuration into substantial conformity with the predetermined configuration.

In accordance with an alternative embodiment of the present invention there is provided a profile bending apparatus including a profile definition system arranged to ensure a profile is bent to a desired shape, the apparatus having profile strip feed means and profile strip bending means, the profile strip means being arranged to feed a profile strip towards a pin mounted upon a rotatable table of the profile strip in operation then being bent by action of the pin against the strip as the table is rotated to a predetermined degree and in accordance with specified strip feed and bend operations controlled by control means, the apparatus including imaging means to view at least a part of the profile strip when fed and bent, the imaging means being interrogated by image grabbing means which create therefrom image data, the apparatus including comparison means to compare the image data from the image grabbing means with similarly formulated desired image data and providing the results of said comparison to the control means such that the control means can generate as necessary correction strip feed and/or bend instruction for the profile bending means to bring the profile strip into substantial conformity with the desired strip shape.

Preferably the profile bending apparatus imaging means is interrogated after each profile strip feed or bend operation.

Preferably the system or apparatus has the profile strip illuminated substantially from above.

Preferably the profile strip is located above a substantially non-reflective surface.

Preferably the imaging means is a charge coupled device (CCD) camera.

An embodiment of the present invention will now be described by way of example only with respect to the accompanying drawings in which:

Fig. 1 is a schematic perspective view of a bending station;

Fig. 2 is a schematic illustration of a profile definition system;

Fig. 3 is an illustration of residual deviation between observed tie points and a reference square grid;

Fig. 4 is an illustration of feed calibration procedure;

Fig. 5 is an illustration depicting the bend error between observed and ideal shapes; and,

Fig. 6 illustrates some typical knife profiles necessary for shoe manufacture.

Fig. 1 illustrates in a schematic perspective the bending arrangement for a profiling apparatus in accordance with the present invention. A retractable pin 21 is located in a rotatable cylinder table 22. A profile strip i.e. knife steel 23 is fed through a feed mechanism 24 and fixed jaws 25. It can be seen that the pin 21 acts against the strip 23 to create incremental bends about fulcrum points 26 after each feed stage from the mechanism 24 and accumulation of sequential bending operations about points 26 create a desired bend in the strip 23 and so a suitable profile.

As the pin 21 is retractable it can be moved either side of the strip 23 and thus bend the strip 23 in either direction. The arc of rotation for the pin 21 is determined by the effect of jaws 25. Thus it is preferable to have as narrow a jaw 25 projection as possible whilst ensuring there is rigid location of the strip 23 to ensure appropriate bending as required. It will also be understood that consideration must be given as to whether the strip 23 will interfere with the lifting of the pin 21 from the table 22.

The two determining factors in a bent profile are the degree of feed through mechanism 24 and the bend angle created by pin 21. It is normal to vary feed length and adjust the bend angle as required. By varying feed length it will be appreciated that any chordal error can be kept to a constant

predetermined tolerance.

As indicated previously if the strip 23 acted as an ideal material and thus was not subjected to the normal mechanical variations present in most materials a simple combination of feed and bend steps would achieve the necessary profile. However, the strip 23 is subject to a wide range of mechanical variations including work hardening, variation in Young's Modulus along its length and other factors. Thus, simple sequential feed and bend steps do not achieve the necessary profile accuracy for a practical knife or similar device.

In particular, it is very difficult to get length of curved section correct, resulting in gross errors in position of identifiable sharp corners (irregularities). This is thought to be due to the difficulty in predicting shape of bent sections and, therefore, their length, accurately.

Fig. 2 illustrates in schematic form a profile detection system necessary for the present invention and has the strip 23 illustrated in expanded form. The strip 23 is located above a non-reflective background 31. A camera 32 with appropriate lens 33 is located substantially perpendicular to the strip 23. An illumination device such as a fluorescent lamp 34 is located to ensure the strip 23 is substantially illuminated only from above. The camera 32 is coupled to an appropriate frame grabber 35 which essentially reviews a predetermined area of the image from the camera 32. Thus, the cutting edge of the strip 23 can be identified and plotted. Typically the frame grabber is coupled to a monitor 36 through which the image from the camera 32 can be shown. The frame grabber 35 is also coupled to image comparison apparatus 37 in which the actual strip 23 profile is compared with a desired profile. Both actual and desired profiles may be displayed on the monitor 36.

The camera 32 is normally a charge coupled device (CCD) based television camera and the lens 33 is typically a 50mm F/1.4 CCTV lens with a working distance of about 75cm to define a digitised field of view about the strip 23 of about 9cm by 6cm. The illumination source 34 is a 20cm diameter ring-shaped fluorescent light fixed about 37cm above the object

plane. As indicated previously in order to minimise light reflection into the camera from the background and so emphasise the strip 23 profile the background is arranged to have little or no reflection. This can be achieved by use of black anti-static foam or possibly with fall away shoulders about the strip 23.

For most effective operation the camera should be arranged such that the image plane is closely parallel to the object plane in order to minimise distortion effects due to tilt but also to make it possible to put the camera back into a known orientation after adjustment of optical factors. The profile 23 is digitised and gives a clear definition of the knife edge. However, as can be seen from the exploded cross-section in Fig. 2 the edge of the profile 23 is normally off-centre. The edge is clearly visible due to spectrally reflected light as a narrow peak superimposed on a background provided by the non-reflective surface 31. Furthermore light from the source striking the area immediately either side of the peak is darker than the background 31 as the chamfered surfaces of the profile 23 reflect light away from the camera 32.

The knife edge under typical conditions can be calculated to about .3 pixels wide. There is a broadening effect due to the lens and the camera sensor. However this broadening effect allows the position of the edge to be calculated to sub-pixel accuracy either by a mean or a most probable value distribution approach.

An algorithm can be used to calculate the mean position of the profile 23 incorporating an estimate for background which is subtracted from each pixel value in order to obtain true intensities. However such an approach is not preferred as it is strongly dependent on signal and background levels and it requires a relatively large amount of calculation for real time adjustment of the profile 23 in formation of a practical configuration. The more acceptable approach is to fit a parabola to the three largest pixel values in the peak and use the calculated position corresponding to the highest value of parabola to define the edge coordinates.

It is necessary to calibrate the image data held in the frame grabber 35 to control the bending process to convert positions extracted from the digital image into real world coordinates. In order to do this transposition, a highly accurate plotted grid was placed on a white background so that it would lie in the same plane as the knife edge. This grid was then rotated manually until it was in alignment with the camera sensor axes to within a fraction of a degree and the image captured by the frame grabber 35. This image was then memorised by the comparison means 37 and the intersections of the lines within the grid calculated as tie points. It will be appreciated that such empirical calibration removes several causes of inaccuracy including lens distortion, frame grabber limitations and small random errors in grid manufacture.

The next stage is to provide a consistent transformation between digitised and object coordinates using these known tie points. The technique used was to apply a geometric transformation comprising an aspect ratio correction and a corrective rotation of the digitised grid lines to achieve best alignment with the horizontal and vertical axes of the camera 32 sensor. Fig. 3 illustrates a typical plot of residual deviation between the optimum geometrically corrected digitised tie points and a perfect square array. These points were generated by determining the euclidian distance between each geometrically corrected tie point and the nearest point from a square array of points in the digitised coordinate system for the grid. Using these points together with a locally defined transformation it is possible to produce a fast accurate and totally reliable transformation between imaged views of the strip 23 and stored descriptions of desired profile configurations.

The imaging apparatus in accordance with the present invention is used to control profile bending. This system is by its nature a closed loop arrangement involving measuring the current shape of the profile edge and comparing it with a stored or required shape and by appropriate consideration estimating a correction to improve the match. In practice the estimation to correct the current shape of the profile edge is

done automatically. Typically the required profile is generated by a computer-aided design system and so it is necessary to convert this information into suitable format for comparison with the current profile shape as captured by the frame grabber in terms of pixels.

As indicated previously the actual bending machine can only perform two tasks namely feeding strip 23 and bending strip 23 thus, the sequence of operations to bend the strip 23 into an appropriate profile must be recorded and performed as appropriate. It is clear that both the speed and length of strip feed could be varied along with the bend angle to bring the imaged profile edge into accordance with the desired profile stored as indicated. However, by introducing two variables the degree of complexity in correcting inaccurate bends is increased and so it is normal to simply correct bend angles only and to rely on pre-calibration to perform each strip 23 feed operation correctly.

The strip feed calibration is a highly important element in ensuring that the profile definition system is accurate as the feed length just beyond the jaws 25 is part of the following knife segment after it is bent by an amount dependent on the magnitude and size of the bend angle. Furthermore the process causes the profile edge which is significantly offset from the neutral axis either to stretch or to contract depending on the size of the bend angle. The strip feed calibration process is illustrated in Fig. 4. The reference point (X_{ref} , Y_{ref}) is the point between the jaws of the bending apparatus and is where the profile breaks off. A known length F of profile is fed through the jaws and bent through an angle . A straight line is fitted to the measured data for the bent profile and its intersection with the line that passes through (X_{ref} , Y_{ref}) along the feed direction is determined. From this intersection, the offset distance Y_{off} which is the amount of fed strip 23 that will contribute to the next segment can be determined. The other distance F_d corresponds to the required length of the current segment. A feed compensation factor defined as $F_d - (F - Y_{off})$ is calculated and accounts for both geometrical and stretching

factors in the formation of the bend. The feed compensation factors and the offset distances measured over full ranges of positive and negative bend angles are necessary in general to calculate the amount of feed strip 23 needed to achieve a particular length of segment. Y_{off} is also needed to compare the required profile shape with the desired shape.

Automatic tracking of the actual profile edge is achieved by analysing each row or column from the frame grabber and only that region within a narrow band centred around the known position of the corresponding part of the required knife shape. This method does not require profile image data to be continuous and functions reliably even when the profile has a corroded or contaminated edge. Since at least the profile nearest the jaws 25 is known the tracking method allows a bend correction to be applied even if the first attempt at a bend angle is wrong by a few degrees, subsequent image capture and tracking after the application of the first attempt bend angle correction enables more of the edge to be located from which an accurate second attempt correction can be calculated and implemented.

Fig. 5 illustrates the approach taken to calculate bend angle correction from a given image. The approach taken is to find the rotational angle which would best align the observed profile edge shape with the required shape. For the i th segment at a point P_i roughly in the middle is first defined and the rotation θ_i about the pivot point B which is needed to take this point onto the corresponding segment of the required shape is calculated. The angle θ_i is weighted using an expression which takes into account the distance P_i to B the length of the segment and the inclination of the segment. A weighted mean value based on all the tracked segments within the field of view of the frame grabber is calculated and taken to be the bend angle correction.

Fig. 6 illustrates three practical knife profiles A, B, C used for cutting leather pieces of a shoe. Each knife shape has been divided into several segments. These segments are then brazed together to form the final knife.

Fig. 6 (a) illustrates a so-called cap shaped knife.

This knife 61 comprises two smooth sections with breaks at points 62,63.

Fig. 6 (b) illustrates a so-called vamp knife which has a much larger size than the cap knife illustrated in Fig. 6 (a) and is made by breaking the shape into four sections depicted by points 64,65,66,67.

Fig. 6 (c) illustrates a so-called quarter knife and again this profile is divided into two pieces by breaking the shape at points 68,69.

Now considering all the Figures it will be appreciated that at the core of the present invention is the frame grabber 35 and typically this device has a 512 x 512 pixel area. However, as the pixels have a rectangular shape the frame grabber generally has a rectangular image area of typically 60 x 90mm.

The turntable 22 upon which the pin 21 is mounted comprises a stepping motor drive and the feed device 24 is connected through a gear box to a second stepper motor and has sufficient pulling power on the strip 23 to draw it through a five-roller flattener to straighten the strip from a coil feed (not shown). The comparison device 37 can be a Z-8002 microprocessor, an IBM PC compatible computer or a transputer and includes necessary control instructions for pin 21 offset compensation when there are previous profile bends between the jaws 25 and the pin 21, i.e. in parts of a profile where feed increments are small. The profile is drawn by a stepper motor mechanism using pneumatically controlled clamps powered through a regulator from a gas supply. The strip is clamped a fixed distance behind the jaws 25 in order to restrain the strip 23 during bending. The flattener is necessary to ensure limited deviation from a straight feed property. Typically desired profile data is in the form of absolute X-Y coordinates given through a CAD interface. It is obviously desirable to ensure that the CAD coordinates and the profile are in a consistent format, i.e. ASCII.

The main elements of the imaging system are the frame grabber 35, the camera 32, the lens 33 and lighting 34. Furthermore, it is important that the background 31 has as

little reflection as possible. The camera 32 is mounted vertically above the profile 23 so that it can see the profile 23 with the least possible geometrical distortion.

In order to improve imaging it is advantageous to remove any protective oil coating on the profile and if possible provide a small degree of edge abrasion. Thus, the knife edge appears white in the frame grabber image store 35.

It will be appreciated that there is a degree of vibrational motion of the profile 23 as it is bent. Vibration is obviously detrimental to accurate image capture. In order to limit such problems typically several images are taken and averaged. Furthermore, a motion sensor is used to monitor the vibrating profile and trigger flash illumination of the profile as the profile crosses its equilibrium position, which coincides with the position at which the vibrating strip achieves its maximum velocity. Additionally, a means of damping the knife steel can be provided.

As indicated previously it is highly important that the stored desired profile data is readily interchangeable and transformable into actual image data format. In microprocessor based control systems typically the ASCII file format or the profile data is used and is transformed into world coordinates X,Y pairs using pre-set processes. The transformation must be consistent so that the sequence of X,Y pair coordinates can be rearranged as desired. From this series of X,Y pair coordinates the microprocessor can then generate an ideal profile to a required accuracy and possibly indicate whether such profile can be achieved with the bending apparatus in use. Furthermore the microprocessor may be arranged such that several attempts by differing strategies may be considered to determine whether the profile can be achieved.

Clearly the bending apparatus is controlled by sending feed and bend values sequentially in an appropriate manner such that the strip 23 is bent as required. Typically after each feed and/or bend operation the image of the profile strip 23 is reviewed and compared in the comparator 37 with the desired profile.

If the strip profile 23 now represented by the captured profile image in the frame grabber 35 is not within the required accuracy when compared with the desired profile the control module is arranged to correct any deficiencies by a combination of additional feed and/or bend correcting operations until the strip 23 profile meets the required accuracy. When the strip 23 profile meets the required accuracy in comparison with the desired profile the microprocessor sends the next command for strip feed and/or bend and the process continues until the entire profile is finished. Furthermore, these additional feed and/or bend correcting operations could be achieved by alteration of existing sequential feed and bend steps.

The imaging system needs to relate three coordinate systems precisely with one another in order to control profile bending, these systems being the profile coordinate system, the computer-aided design world coordinate system and the screen frame grabber coordinate system. When the camera 32 views a profile shape the profile screen coordinates must be expressed in the object coordinate system in order to compare it with the corresponding computer-aided design pattern.

The focal length of the camera 32 is determined as a compromise between the conflicting requirements of a large field of view to image as much as possible of a complete profile and adequate image resolution. The camera 32 image plane is aligned parallel to the object profile plane.

For profiles that define shoe patterns which are designed by a computer-aided design system each knife profile is specified by a parametric spine curve identity (PSCI). This knife pattern data is then specified or transformed into ASCII format and stored as appropriate. It is then transformed yet again into X,Y coordinate pairs based on the image system world coordinate system. Subsequently this profile is further specified as a sequence of strip 23 feed and bend commands along with values which can be followed by the bending apparatus.

Vibration damping in the present invention can be provided with a multitude of bristles, spines or other fibroid

structure. In use, these bristles 5 at least partially envelope one edge of the strip 23. Thus, these bristles provide partial resistance to lateral movement of the section 2 and so dampen vibration. However, it is important that these bristles do not or are not capable of holding the strip under any load such that the strip is either distorted or held at a position other than its free configuration relative to the jaws of the automatic knife bending apparatus. It will be appreciated that if the strip were held in such a distorted or non-free configuration then the actual image seen by the camera for comparison with the desired knife configuration would be incorrect and lead to an erroneous actual knife being produced.

It has been found that bristles in excess of 10mm provide acceptable results with about 50% of the strip width enveloped by these bristles. However, it will be understood that variation in bristle strength, strip flexibility and expected bend operations will affect the choice of bristle length and strength.

One approach is to arrange that the bristles are only present outside of the viewed field of the camera thus avoiding problems of light reflection by the bristles. However, if the bristles are black and dull these problems can be removed and the bristles can also be present in the viewed area.

It may be arranged that the bristles permanently envelope part of the knife strip. However, it is possible that such permanent engagement may be inconvenient when feed and bending operations are being performed. In order to remove this problem it is possible to drop the bristled surface out of engagement with the knife strip during feed and/or bend operations and raise this bristled surface after each operation to provide damping. This facility will also allow variation in damping effect by varying the extent of bristle engagement with the knife strip in terms of the width of strip enveloped.

Furthermore, bristled surfaces could be provided in parallel either side and perpendicular to the strip. Thus,

the strip could be engaged through enveloping both opposed edges.

Alternative means of ensuring the bristles are non-reflective are to produce the bristles of non-reflective material or coat them in such material, ensure for example the illumination light was red and the bristles an indistinguishable blue, or by providing the bristles at an inclined angle so limiting the reflective surface available. Typically, with this later alternative the bristles will be inclined at an angle of 45° although other angles could be used. As with vertical bristles, inclined bristles envelope to a predetermined extent at least one edge of the knife strip and so dampen vibration after each bend/feed operation.

Other aspects and features of the present invention will be understood by those skilled in the art.

Claims:

1. A profile definition system for control of knife profile formation produced by forming apparatus arranged to bend suitably fed profile strip characterised in that an imaging device is placed in a substantially perpendicular relationship with at least a part of the profile strip such that an image of the profile strip configuration can be compared with a predetermined configuration stored in comparison means and said comparison means being arranged to adapt said forming apparatus operation as a result of such comparison to bring said profile strip configuration into conformity with the predetermined configuration.

2. A profile bending apparatus including a profile definition system arranged to ensure a profile is bent to a desired shape, the apparatus having profile strip feed means and profile strip bending means, the profile strip means being arranged to feed profile strip towards a pin mounted upon a rotatable table of the profile strip bending means, the profile strip in operation then being bent by action of the pin against the strip as the table is rotated to a predetermined degree and in accordance with specified strip feed and bend operations controlled by control means, the apparatus including imaging means to view at least a part of the profile strip when fed and bent, the imaging means being interrogated by image grabbing means which create therefrom image data, the apparatus including comparison means to compare the image data from the image grabbing means with similarly formulated desired image data and providing the results of said comparison to the control means such that the control means can generate as necessary correction strip feed and/or bend instructions for the profile bending means to bring the profile strip into substantial conformity with the desired profile shape.

3. A profile bending apparatus as claimed in Claim 2 wherein the imaging means is interrogated after each profile

strip feed or bend operation.

4. A system or apparatus as claimed in any preceding Claim wherein the profile strip is illuminated substantially from above.

5. A system or apparatus as claimed in any preceding Claim wherein the profile strip is located above a substantially non-reflective surface.

6. A system or apparatus as claimed in any preceding Claim wherein the imaging means is a charge couple device camera.

7. A system or apparatus as claimed in any preceding Claim wherein the actual knife edge which is used for comparison with the predetermined configuration.

8. A system or apparatus as claimed in any preceding Claim wherein a vibration sensor is used to determine the extent of profile vibration in order that appropriate adaptation of the image data to limit any detrimental effect of profile vibration is made by the comparison means.

9. A system or apparatus as claimed in any preceding Claim wherein vibration damping means is provided for said profile strip.

AMENDED CLAIMS

[received by the International Bureau on 24 April 1996(24.04.96);
original claim 1 amended; remaining claims unchanged (2 pages)]

1. A profile definition system for control of knife profile formation produced by forming apparatus arranged to bend suitably fed profile strip by progressive cumulative deformations characterised in that an imaging device is placed in a substantially perpendicular relationship with at least a part of the profile strip such that an image of the profile strip configuration can be compared with a predetermined configuration stored in comparison means and said comparison means being arranged to adapt said forming apparatus operation as a result of such comparison to bring said profile strip configuration into conformity with the predetermined configuration.

2. A profile bending apparatus including a profile definition system arranged to ensure a profile is bent to a desired shape, the apparatus having profile strip feed means and profile strip bending means, the profile strip means being arranged to feed profile strip towards a pin mounted upon a rotatable table of the profile strip bending means, the profile strip in operation then being bent by action of the pin against the strip as the table is rotated to a predetermined degree and in accordance with specified strip feed and bend operations controlled by control means, the apparatus including imaging means to view at least a part of the profile strip when fed and bent, the imaging means being interrogated by image grabbing means which create therefrom image data, the apparatus including comparison means to compare the image data from the image grabbing means with similarly formulated desired image data and providing the results of said comparison to the control means such that the control means can generate as necessary correction strip feed and/or bend instructions for the profile bending means to bring the profile strip into substantial conformity with the desired profile shape.

3. A profile bending apparatus as claimed in Claim 2

- 19 -

wherein the imaging means is interrogated after each profile strip feed or bend operation.

4. A system or apparatus as claimed in any preceding Claim wherein the profile strip is illuminated substantially from above.

5. A system or apparatus as claimed in any preceding Claim wherein the profile strip is located above a substantially non-reflective surface.

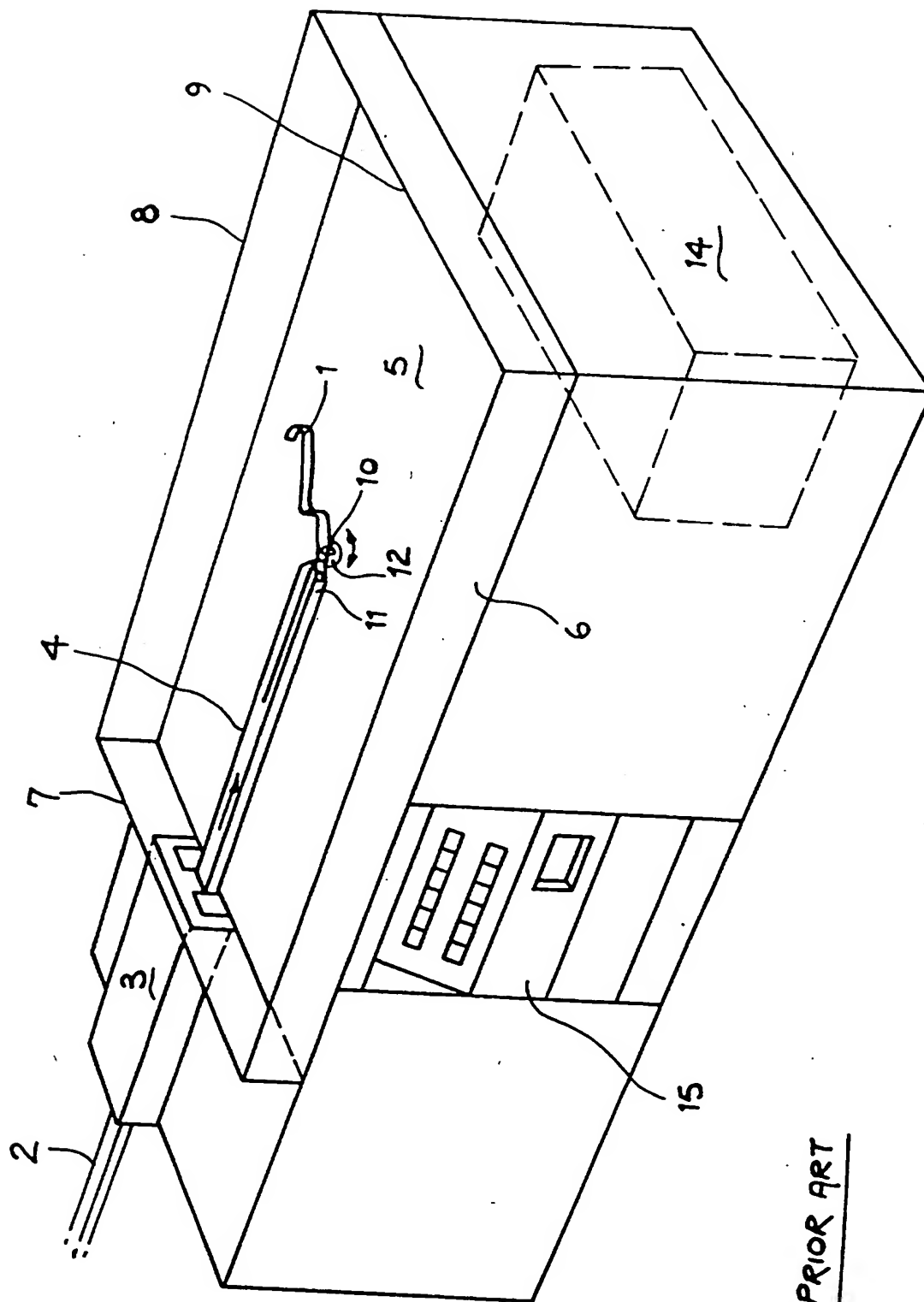
6. A system or apparatus as claimed in any preceding Claim wherein the imaging means is a charge couple device camera.

7. A system or apparatus as claimed in any preceding Claim wherein the actual knife edge which is used for comparison with the predetermined configuration.

8. A system or apparatus as claimed in any preceding Claim wherein a vibration sensor is used to determine the extent of profile vibration in order that appropriate adaptation of the image data to limit any detrimental effect of profile vibration is made by the comparison means.

9. A system or apparatus as claimed in any preceding Claim wherein vibration damping means is provided for said profile strip.

1/4



PRIOR ART

2/4

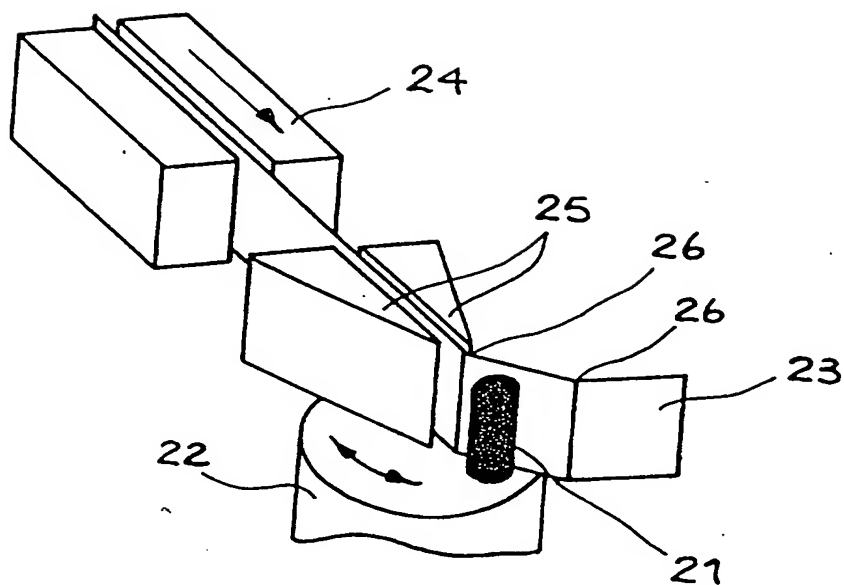


Fig-1

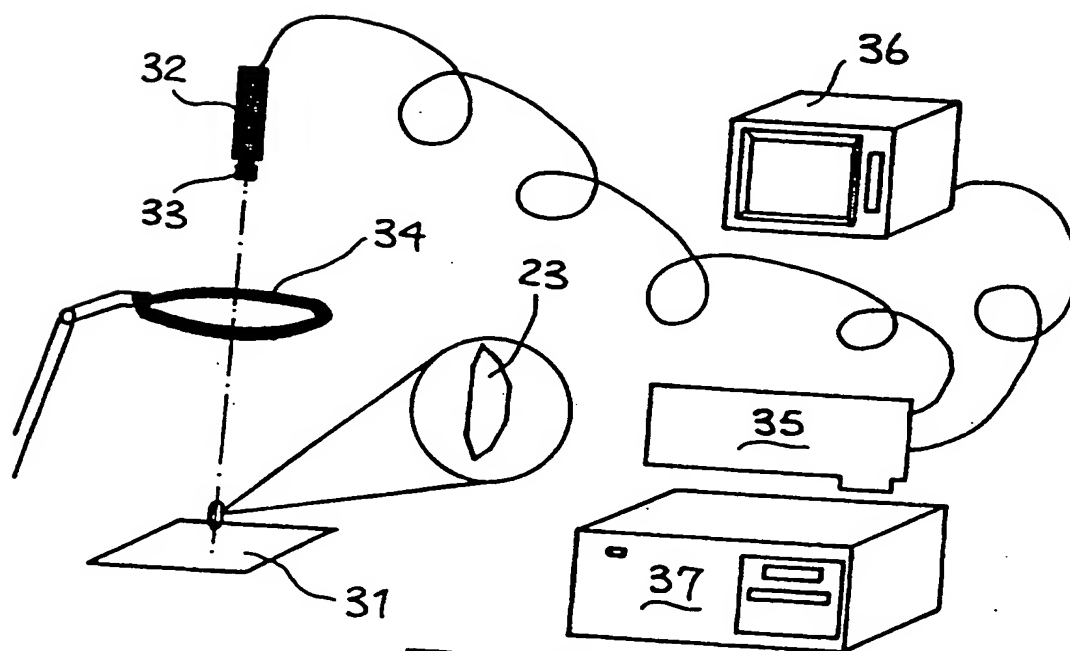


Fig-2

3/4

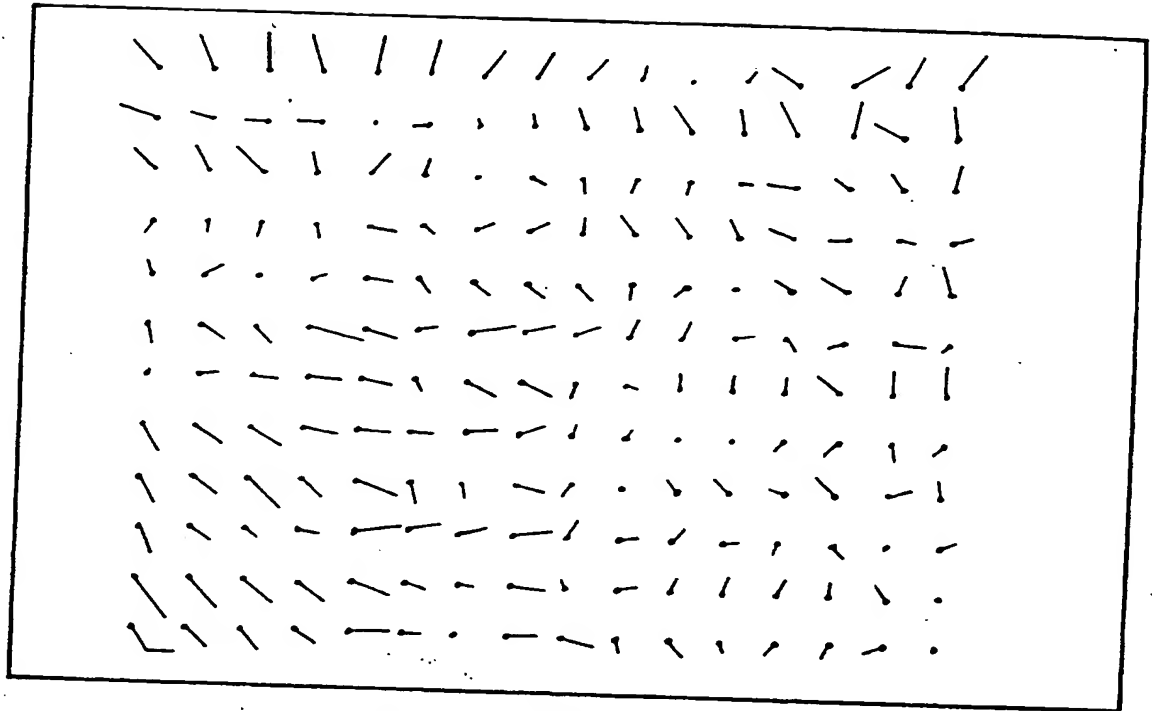


Fig- 3

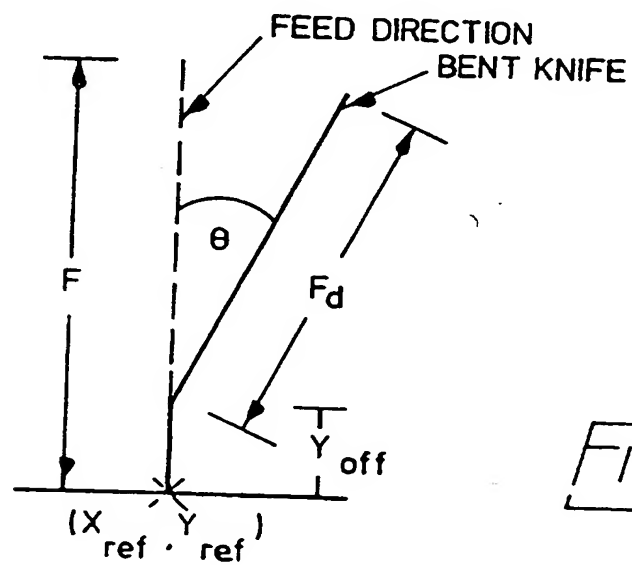


Fig- 4

4/4

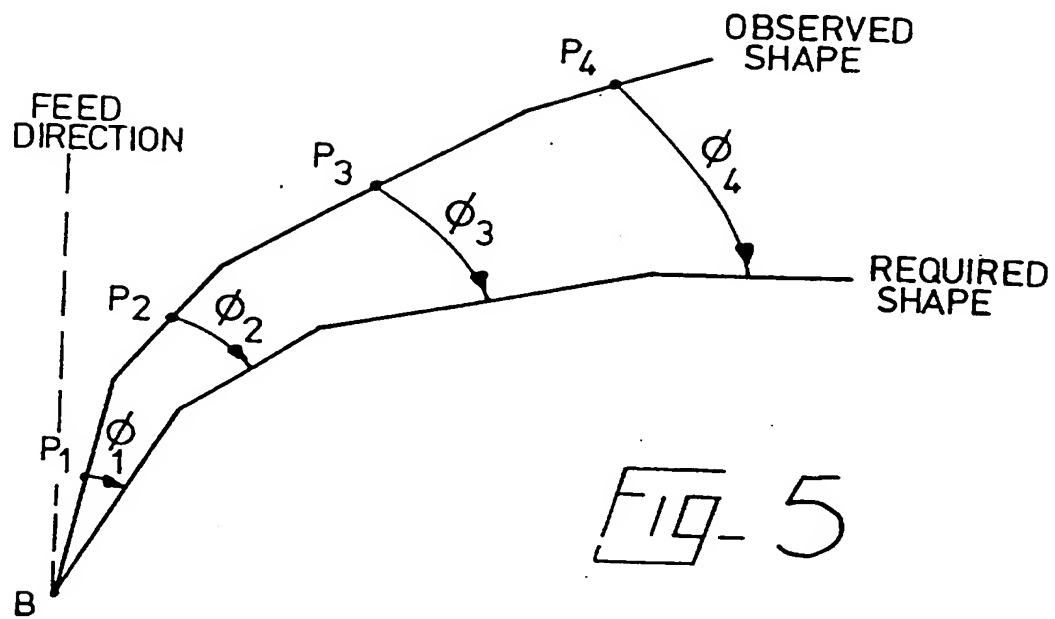


FIG-5

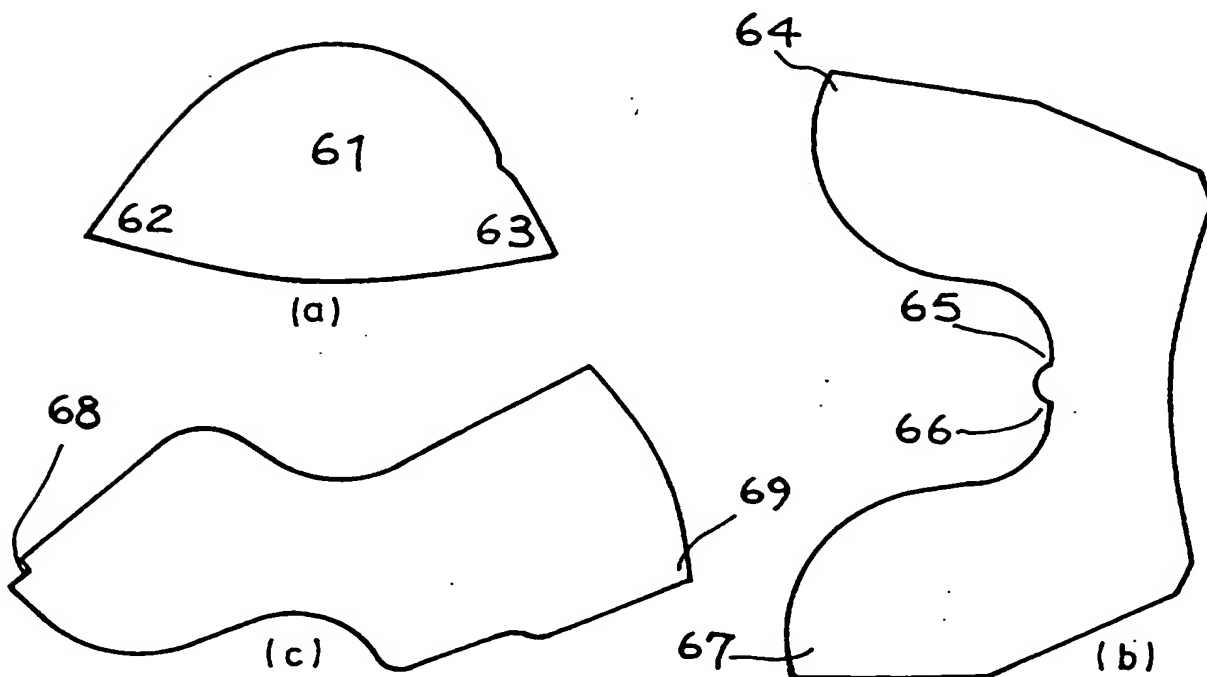


FIG-6

INTERNATIONAL SEARCH REPORT

Int. al Application No

PCT/GB 96/00018

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 6 B21D11/10 B21D53/64

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB,A,2 116 086 (PA MANAGEMENT CONSULT) 21 September 1983 cited in the application see the whole document ---	1-3,6
Y	DE,A,41 09 795 (BURGER GEORG) 1 October 1992 see the whole document ---	1-3,6
A	PATENT ABSTRACTS OF JAPAN vol. 009 no. 261 (M-422) ,18 October 1985 & JP,A,60 108116 (AMADA:KK) 13 June 1985, see abstract --- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

22 March 1996

Date of mailing of the international search report

03.04.96

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Authorized officer

Peeters, L

INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 015 no. 199 (M-1115) ,22 May 1991 & JP,A,03 052717 (AMADA CO LTD) 6 March 1991, see abstract ---	
A	PATENT ABSTRACTS OF JAPAN vol. 016 no. 157 (M-1236) ,16 April 1992 & JP,A,04 009217 (AMADA CO LTD) 14 January 1992, see abstract ---	
A	PATENT ABSTRACTS OF JAPAN vol. 016 no. 157 (M-1236) ,16 April 1992 & JP,A,04 009218 (AMADA CO LTD) 14 January 1992, see abstract -----	

In. **al Application No**
PCT/GB 96/00018

GB-A-2110096	21-09-83	NONE
DE-A-4109795	01-10-92	NONE